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A very warm welcome to all of you. I am Rajan Chaudhary, a professor in the Department of Civil Engineering at the Indian Institute of Technology, Guwahati, and an instructor for the NPTEL MOOC course, Pavement Construction and Technology, funded by the Ministry of Education, Government of India. Now, today's lecture will be a part of module 2 of this particular course, and it will be on bituminous-bound courses and their functions. At the very beginning, I would like to acknowledge the use of text, information, graphs, and images sourced from various textbooks, codal standards, journal articles, reports, newsletters, and public domain searches. Now, when the term "bituminous bound layers of flexible pavements" or "bituminous bound courses of flexible pavements" comes into the picture, the first term that arises is bitumen. What is that bitumen? Bitumen is a binding material that is very widely used in the construction of flexible pavements to create bounded layers, and this particular material is often referred to as black bitumen, which is a black semi-solid state; there are different sources of bitumen, and we will discuss these in our upcoming lectures.

So, it is a viscoelastic material that is semi-solid at ambient temperatures; when you heat it, it becomes soft and pourable. So, it looks black in color. Known by different names, such as bitumen and asphalt, you will also find the term asphalt cement. And since it is the costliest component within the flexible pavement, many times we refer to it as black gold by pavement engineers as well.

And it forms a key binding material. Since the bounded layers that we are going to make will be used in the top courses of flexible pavements, this bitumen is used as the binding material, and when you use this bitumen along with the aggregates to form a mix, it becomes a bituminous bonded mix or, we can say, a bituminous bound course. Now, most of the aggregates have very good bonding with bitumen. So, this is one additional advantage: throughout the globe, this bitumen has been very popular for use as a binding material with different kinds of aggregates. Now, in a pavement structure, we discussed the subgrade and the unbound courses.

When we move up, this is our natural subgrade, which means natural soil or embankment; then we have our compacted subgrade. After that, we have the granular courses, followed by the unbound base courses or bituminous bound courses, and then some binder course, with the wearing course or surface course on top. Now as you go to the top, the stresses keep on increasing because the upper layers experience higher stresses compared to the

lower layers. So we want our upper layers to be stronger, and they will be exposed to severe climatic conditions; they will be exposed to higher temperatures. The topmost layer will be exposed to continuous abrasion by the vehicle tires.

This will be exposed directly to the sunlight and will be exposed to water also. So, their exposure to different climatic conditions and the stresses that are going to take place because of the vehicle loads will be higher in the upper courses. So, that is why we want these upper courses to be stronger and more resilient. So, while moving upward in the pavement crust from the subgrade, the intensity of stress increases, necessitating stronger and more resilient pavement layers to effectively withstand the applied loads; this is important. And here comes the role of the bitumen; it gives us a binding material that is flexible and has been used in various other applications, such as making structures or as a water-repellent and waterproofing material.

So, this is when this combination of aggregate along with the bitumen gives you a good strength mix with very good strength. which has good cohesion and is able to sustain different environmental and loading conditions. So, that is why these bitumen bound courses play a very important role in the structural integrity as well as in the functional requirements of a flexible pavement. The bituminous bound courses are mainly used in flexible pavement, and the three layers in which they are typically used form over the top course, which we call the surface course or bearing course, and the intermediate course, which is your bituminous binder course, and a bituminous base course. So, the bituminous base course is the one that comes over your granular courses, and then a bituminous binder course is the one that comes between your existing bituminous layer and your top surface course.

So, this bituminous binder course is your intermediate bituminous layer. So, the bituminous binder course is the intermediate layer between the bituminous base and the bituminous surface. So, these are the three layers; all three layers are constructed using bitumen as the binding material. Now you can see these are the unbound granular layers; then here there are two layers, which are the two layers that have bitumen as the binding material. Now, what are the main functions of these bituminous bound layers? As I mentioned, these are the layers that are going to bear the maximum stresses on top.

So, they should be able to provide sufficient structural strength and durability since they will be exposed to different environmental temperatures, climatic conditions, various loading conditions, different axial loads, and different speeds, because moving at different speeds will also be encountered. Or the upper layers will be subjected to higher variations compared to the lower layers. So, they need to provide sufficient structural strength and durability to the pavement to withstand heavy traffic loads under varying environmental conditions. Other aspects need to be strong enough so that they can distribute the load over

a wider area, specifically to reduce the stress intensity on the lower granular and unbound layers and keep it within their load-bearing capacity when it comes to the soil subgrade. And when it is used as the wearing course, top course, as I said, this will be subjected to continuous movement of traffic.

So, we want a smooth surface, which means good riding quality, and it should be able to provide good skid resistance. Otherwise, this kind of thing should not occur, that when you apply the brake, your vehicle skids on the surface. You do not want this kind because this kind of thing will make your movement over the surface unsafe. The other part is that there will be continuous rubbing taking place between the surface and the vehicle tire. So, the surface will become abraded.

So, it should be resistant enough to bear this abrasion, and nowadays another requirement posed at many locations, especially in urban sections, is that the noise generated by the movement of these vehicles over the surface should also be low. So, these bituminous bound courses, which are used on the surface course, should produce low traffic and tire-pavement interaction noise; we can refer to it in those terms. In addition to this one, it should act as a waterproof barrier; this should be dense enough for a layer that is impermeable, so that water does not enter into the underlying layers. Because that damages the structural integrity or the strength of the underlying layers. So these are some important functions that are to be served by these bituminous bound courses, which are typically used as surface course, binder course, and base course.

Now what are those different types of mixes that are used in these courses? When we start with the base courses, the two mixes that are quite prevalent in their use as a bituminous base course are bituminous macadam and dense bituminous macadam. We will see what a dense bituminous macadam is in the upcoming slides and what a bituminous macadam is. Then the one that is very frequently used in the bituminous binder course is your dense bituminous macadam. So you can see that dense bituminous macadam is used in both base courses and binder courses. Now, when it comes to the top course, your surface course, there are good options of mixes available.

Now, these mixes serve various different kinds of purposes and are suitable for different situations; we will discuss some of the important mixes in the upcoming slides. The first one you can see is a bituminous concrete mix, the second is a stone matrix asphalt, the third one is a gap graded mix with rubberized bitumen, this is a specific type of bitumen, then we have semi semi dense bituminous concrete, then we have open graded friction course mix, mastic asphalt, premix carpet, and mix seal surfacing; these are certain mixes that are typically used for low volume roads. These premix carpets, mix seal surfacings, surface dressings, or some renewal codes are there. At the most popular locations, you can see that bituminous concrete is very common, while stone matrix asphalt is a widely used mix,

especially for national highways, state highways, and heavy-duty pavements like expressways. Now this table can give you a better idea about it.

This is a table taken from IRC 37-2018, which states that if you have a design traffic greater than 50 msa. An under-surface course should preferably use stone matrix asphalt or a gap-graded mix with rubberized bitumen or a bituminous concrete mix. So, you can see this when there is higher traffic. These three kinds of mixes are advised to be used as a wearing course when the traffic is again lesser in magnitude, that is, in the range of 20 to 50 msa. Again, these three mixes are prescribed, but there will be a difference in the type of binder that has been used.

So, like what has been prescribed, there may be a slight difference in the binder types depending upon the category of road; even if the traffic is less, if it forms a national highway, then you will prefer to go for these high types of surface courses. Now, when the traffic is less than 20 msa, it states that you can also use bituminous concrete, semi-dense bituminous concrete, premix carpet, mix seal surfacing, and surface dressing; these are the three mixes that have been shown here. And along with it, for these different levels of traffic, it mentions what can be used in your base courses and binder courses. As I said, these base and binder courses here indicate that DBM can be used both as base and binder courses for this traffic level; it can also be used for base and binder courses when it comes to very low traffic. Here, the other term that is mentioned is bituminous macadam.

For the rest of the cases, we have seen that most of the time dense bituminous macadam is referred to as a base and binder course. Bituminous macadam is referred to as the binder course only when the traffic is less than 20 msa. So, we mentioned that we have different categories of mixes falling under the base course requirement, the binder course requirement, and the wearing course requirement. One classification for these bituminous bond mixes comes in terms of their denseness, which is based on the selected aggregate gradation. Now you can see here that three different types of gradations have been shown, and specifically, the first one is your dense-graded bituminous mixes.

Second are your gap-graded bituminous mixes, and third are your open-graded bituminous mixes. Now all are bituminous-bound mixes, but they have different characteristics in terms of their denseness. Now, you can see the dense graded bituminous mixes you will find here; in this case, one bigger aggregate particle will be packed with smaller aggregate particles, and the voids of the smaller particles will be further packed by even smaller particles. So, you have the distribution of different sizes. So, if I show the aggregate distribution or aggregate size distribution for a dense-graded one, it goes in a similar fashion.

So, it is somewhere like an S curve, which you might have studied in the case of soil characterization as well. So this distribution gives me a range of sizes in all distributions.

And here, if I put the classification in terms of coarse aggregates, which are greater than 2.36 mm in size, in pavement engineering or bituminous mixes, the classification is in terms of 2.36; it states that coarse aggregates are those that are greater than 2.36 mm in size. Fine aggregates are those that fall in the range of 2.36 to 0.075 mm, or this can be called 75 microns, and whatever passes through this 75 microns will be your filler. So, in a dense graded mix, you typically have around 50 percent of coarse aggregate, 43 or 45 percent of it, and 5 to 8 percent of your filler; when it comes to gap graded, some typical sizes are removed. Here you can see that within this range, there is not a significant change in the percentage passing.

So, that is why some of these sizes are missing in this gradation. So, this is what is here because a major share is 80 percent coarse aggregate, then fine aggregate and filler, because ultimately they also need to be made dense. So, whatever voids get created need to be filled up with finer materials, but we are missing certain sizes and keeping some of these lower fractions or fillers more. So, that ultimately also becomes dense, but not with intermediate sizes while keeping the lower sizes. So, the specific purpose of doing this is to add more coarse aggregates to bring more contact points, especially in these coarse aggregates.

So, these are load-carrying skeletons, I would say. So, I want to have more coarse aggregates and more contact points between this one. So, that is what the gap-graded mix is. When it comes to open graded, my specific purpose here is to generate a greater amount of air voids. Now, in this case, you can see this is an open-graded one.

So the open-graded one, this blue one, is my open-graded one. The entire major part lies within this particular range only. So it is a uniform size of aggregates. You can see 92.5 or 93% of coarse aggregate only, and the remaining is only around 7 to 8%.

So that shows that this is more of a uniform aggregate gradation. A lot of voids will be present in this kind of mix. So, our discussion helps us understand the gradation we can achieve by combining mixes with different distributions of aggregates within them. So, we can have dense-graded one, we can have gap-graded one, and we can have open-graded one. So, let us just go with the different kinds of mixes, the one which, as I mentioned, is for low traffic of less than 20 MSA: a mix of bituminous macadam, which is referred to for use as a base course mix.

What is that particular mix? So, bituminous macadam is typically referred to as an open graded mix, as I mentioned, because you will find the aggregate gradation has more voids compared to what is there for a dense graded one. And that is why it is typically the case that as you go down granular courses, they will have more air voids compared to what you have in your binder course or your bituminous bound base courses. And there is no specific

design; it is a sort of recipe mix that is to be followed, and the design is to be as per IRC 27-2009. Now, if I look at what the typical range of air voids we expect is when the mix is prepared. If the compacted mix is in the field, then a dense bituminous macadam mix or a dense bituminous concrete mix may have air voids in the range of 3 to 5 percent.

On the other hand, the bituminous macadam mix can have voids in the range of 20 to 25 percent, which is quite high. So, this high range of air voids makes these mixes permeable to water. Now, when you are using this permeable bituminous macadam as a binder course, you have to be cautious enough because, as mentioned, during the drainage layer as well. If some water enters through the surface or through the sides for any reason, then this particular layer, which will be your bituminous macadam layer that is quite porous because it has 20 to 25 percent air voids, will hold water. Now, in that case, I should have some proper measures on the sides under the shoulders to drain this water away from this one, as I did in the case of the drainage layer.

So, similarly, it has to be taken care of for the bituminous macadam base course also when you are using this particular course in the flexible. If not, then there is a chance that the water gets trapped in the bituminous macadam, damaging the structural integrity. So, like you do for the drainage layer, extend the provision for the removal of water from the bituminous macadam course as well. Gradations, as mentioned, have been specified for bituminous macadam; what gradations can be preferably used, and what sizes can be? Is an open-graded, there is a potential that it may trap water or moisture within the pavement system. So, it is also mentioned in the MoRTH specifications.

Therefore, adjacent layers should have proper drainage quality to prevent moisture-induced damage to the beam. So, this needs to be properly taken care of in the field during the construction of bituminous macadam. Now, here you can see why a recipe mix is given; it already mentions that you prepare a mix at this binder content level and this particular second gradation. Now, these two gradations specify two different sizes, especially the nominal maximum aggregate size (NMAS): one is for 19 mm and the other is for 80 mm. So, normally we want a layer thickness to be at least two to three times the NMAS.

So, that is why if NMAS is 19, I would prefer to use a layer that is around, say, 60 mm in thickness. So, this gives me, and there it says if you have this aggregate gradation, it is preferable to use 3.3% binder content. So, it is already given that you go with this one, but this is for most of the common specific gravities of aggregates we encounter if the aggregates' specific gravity is around 2.75; if they have a high specific gravity, then you can reduce the binder content.

And, if you have some colder regions where you want to be more specific, where most of the temperatures are below 20 degrees or 10 degrees Celsius, you may have to increase your binder content as well. So, that is why these mixes are called recipe mixes. Now, when

it comes to dense-graded bituminous mixes, which are used again for higher traffic, they are used as a binder course as well as a base course. Now, we will get an idea of how it looks; we can have these two images. Here, you can see there are various sizes of aggregate particles.

Coarser, smaller, then fine dust is there; only aggregate particles are shown. You can see this matrix; you have coarser aggregate particles, a coarser particle, coarser particles, finer, and finer particles. Then some of the fines get embedded into your bitumen, forming a bitumen matrix, which we also call a filler bitumen mastic. So it is a matrix that is formed with the filler, fine aggregate, and binder. Dense graded aggregate structures are perhaps the most commonly used gradation to construct the structure of primary low-transferring bituminous bound courses.

This is the preferred gradation for the construction of flexible pavements. These mixes consist of aggregate particles of various sizes packed progressively into each other. So, this gradation is important to achieve a density, the desired level of density, or the desired level of impermeability to water when it is made with the bitumen. And how this load transfer ability is developed is because you develop this matrix where you will have stone to stone, there will be friction between these stones, there will be a cohesive matrix that will be developed, and the aggregate particles get interlocked with each other. Mixes like binder and wearing courses are laid over the previously laid bituminous binder course, as the previously laid bituminous binder course is the intermediate layer.

So, what is there if I have a granular course this one over that particular one? The first part will be my binder course. So, I will not be sorry; the first part will be my base course. Base course, which is a bituminous base course. So, over the granular course, my bituminous binder course will come, and then my wearing course or surface course will come; all have bituminous binding material. So, base courses will come over granular courses, binder courses do not come directly over granular courses, and binder courses require an existing bituminous course to be constructed over it.

The use of dense graded bituminous mix in the construction of flexible pavements is quite common throughout the globe. It is not that it is in India; throughout the globe, this is very commonly used, and IRC codal guidelines IRC 111-2009 suggest three types of mixes under this particular category. One is dense bituminous macadam, the second is semi-dense bituminous concrete, and the third is your bituminous concrete. And they specifically give guidelines on where you can use DBM as base and binder courses. So, one layer can be considered as depending upon the gradation which is used; I will show you later that one gradation can form a binder base course, while the second gradation may become the binder course of DBM.

So, DBM mixes will have different aggregate gradations depending on the sizes of aggregates that are allowed for in that particular course. Then you have semi-dense bituminous concrete, which is preferably used as a wearing course, and bituminous concrete, which is also used at the top, if I look like. When we go from the base courses to binder courses and wearing courses, the size typically gets reduced, and you make your mixes finer and finer, so you get a smoother surface on the top and a denser surface on the top. And this is a normal consumption; depending upon the mix types, it may slightly vary, but if you have a larger aggregate size DBM, it looks like this. If you have slightly smaller aggregate sizes, this is a semi-dense bituminous concrete, and this is a bituminous concrete.

So, from the top visibility of these three mixes, you can get an idea: here you are seeing bigger aggregate particles; here you are seeing still some less fine aggregate particles than in bituminous concrete highly dense surfaces. Now, as I mentioned dense bituminous macadam, the IRC Triple One suggests two gradations for it: one is your DBM-1, and the second is DBM-2. What these two are is that they differ in terms of the NMAAS, which is the maximum nominal aggregate size that can be used in this particular one. Now this is a one-inch aggregate size; if I use a one-inch aggregate size, I can construct a layer that has to be from 50 to 75 mm. And if I am using a one and a half inch aggregate size as an anemone, I have to have a layer thickness from 75 to 100.

These depend on anemes, and then anemes gradation ranges show how the gradation must vary with respect to the different sieve sizes. Now again, this will, when we come up with the design of bituminous mixes, come to this particular aspect. Now, if I need to have three courses, this is if I have a granular course. I will call this a wet mix mechaderm, which is my granular base course, over which I want to have a bituminous base course. So, I will prefer to use a DBM-1 here, but the layer thickness should be in the range of 75 to 100.

I would prefer a finer one, such as a DBM-2, for that case. So this will become my binder course, and the layer thickness will be in the range of. Now this layer thickness is decided when we look for the pavement design, the design of your pavement crust. But I can assume these values; I can assume, say, that I will assume 80 mm thickness for my bituminous base course, I will take, say, 70 mm thickness for my bituminous binder course, and then I need to provide a wearing course, which may be your BC or which may be your SMA as well. So, this is how I can pick up these gradations and construct my base courses, binder courses, and wearing courses. Now, in this one, it is also very important to smartly pick the gradations that are more usable.

See, in the previous case, we have mentioned DBM-2 gradations one and two. And in one case, the aggregate had a size of one and a half inches as NMAAS, and again, this had a size of one inch. So, when I am talking about this particular one, I have to be cautious enough about what challenges may be there if I am using DBM-1 and what challenges may be there if I am using DBM-2. Normally, it has been experienced that when you use larger aggregate

sizes or a gradation with higher NMS, segregation is more pronounced. This means you will find some honeycombing structures, where the coarse aggregates accumulate with fewer fines compared to other portions of the surface.

So this is a segregated surface. This happens more often when you have larger aggregate sizes. Now, this kind of difference in the aggregate gradation may make your mix more permeable to water compared to what you expect overall from the mix. So if a chance is given to you, you can choose to use DBM-2 as your base course, and then follow whatever gradations you have; you can go for some other mix as your binder course, followed by the wearing course that I will show you when I come to the next slide with bituminous concrete. How this is important is that if I see how NMAS is affecting what the maximum aggregate size is affecting, if that is increased for the same mix, and if one mix has an NMAS of, say, 12 mm while the other mix has an NMAS of 25 mm, the chances are that for the same level of air void content, the mix may have significantly higher permeability because of the segregation-related issues. So, even though a good number of mixes are given to you, the engineer has to be smart enough to pick up which one is the right one, as it is similar to the products available in the market that give you the maximum benefits.

Now, as I mentioned, if I choose a dense bituminous DBM-2 because this mix has a 1 inch or 25 mm NMAS compared to the earlier DBM-1, which had a 1.5 inches. Now, if this forms the base layer, then what will be my binder layer? So, I have two gradations for bituminous concrete, which is also used as a wearing course. Now, here you can see there are two gradations; again, these two gradations vary in terms of their NMAS: one is 19 NMAS and the other is 13.2. In that particular case of DBM, it was 37.5 and 25 mm NMAS. So, if I have these two options, then instead of what I picked, I picked up this NMAS one for my base course. Now, within these particular two gradations that are available, I will prefer this one with 19 mm NMAS as my binder course. So, I will make this my binder course, and on the top, I will have this one as my varying course. So, it says that the layer thickness can be around 50 mm and can be from 25 to 40 mm. So, now I can have a DBM-2, which can have a layer thickness, say, around 60, followed by a BC-1, which can have a layer thickness of 50, and followed by a BC-2 as a wearing course with a layer thickness of 40.

So, this makes three combinations for me. So, we need to be smart enough to pick up which gradation of these different mixes can be used in different layers as a bituminous bound course, bituminous binder course, and bituminous wearing courses. Then, the other layer, as I mentioned, is the semi-dense bituminous concrete, mainly referred to for use as a bearing course for low volume roads or where the traffic is less, or in urban sections as a renewal code. Because you can see, there are also two gradations of semi-dense bituminous concrete, SDBC-1. So, you have options; you have to be smart enough to choose which option and which combination to pick at different layers. Again, it says if the NMAS is 13 mm, then you can go around 3 times it; the layer thickness should be at least 40 mm.

If this is 9, then the layer thickness should be around 25 mm, which means 2.5 to 3 times the NMAS should be your layer thickness. Here, when it comes again to 19, the layer thickness of BC, as discussed earlier, should be in this particular range; when it comes to 13.2, it should be 25 to 40 mm. Now, semi-dense bituminous concrete is the important difference. The word itself signifies that it is not as dense as regular bituminous concrete.

It is semi-dense bituminous concrete. Now you have to be smart enough to address the challenges related to waterlogging problems and heavy rainfall regions where the traffic is very high. You should prefer to use bituminous concrete mixes over semi-dense bituminous concrete mixes. Because you will see the fines, you will find certain fines are missing, or missing means the stress on this particular one is comparatively less. You can see if I pick up any gradation, which is, say, 13.2 for semi-dense bituminous concrete and 13.2 for bituminous concrete. You can see if 1.18 is picked up; my requirement is that 15 to 30 percent of this material should be finer than this 1.18 mm. Whereas in the case of bituminous concrete, it states that 34 to 48 percent should be finer than this.

So I am making it finer and denser. So bituminous concrete 2 with the same NMAS can give you a denser surface compared to semi-dense bituminous concrete 1. Now the other important mix, which is your stone matrix asphalt, is quite popular specifically because of its special characteristics. As I said, this falls under the category of gap-graded one. Gap graded, I am picking or removing specific sizes out of the aggregate gradation to bring more contact between the bigger aggregate particles. So, there should be more stone-on-stone contact within the larger aggregate particle sizes, which I want to improve for better load transfer.

So, stone matrix asphalt is why I will intentionally try to skip some peculiar sizes. So, it will be called a gap-graded bituminous mix because I want to have more contact between larger aggregate sizes or larger aggregate particles so that the load transfer can be sufficient and the load transfer mechanism is strong enough to take higher axial loads. So this gives me a high resistance to rutting, and in these kinds of mixes, we use higher filler material and higher binder content to hold the aggregate particles. So, a matrix that is formed has good cohesive strength, and because of the higher binder content, it is more resistant to the damages caused by the environment or by sunlight. So, we call them the aging resistance is also very high. So, this gives you a mix that is good enough, flexible enough, stiff enough, and has good aging resistance, and it forms a popular choice, specifically recommended when traffic is more than 50 MSA by IRC 37.

So, as I mentioned earlier, they have a good share, specifically a higher share of coarse aggregate particles, compared to otherwise dense graded, which have a much bigger share of fine aggregates. So, here the fine aggregate particles are removed; that means a gap gradation is created to have more contact between coarser aggregate particles. So, this is how it can look; you can see how the bigger aggregate particles are. So, more contact points

between the bigger aggregate particles are developed for better load transfer to make this mix stronger compared to your conventional dense graded bituminous concrete mixes.

So, it gives us a stone-to-stone contact; this is what is expected. Coarse aggregate particles here are in contact with each other due to the reduced fine aggregate proportions and a binder-rich matrix. I will add more fines; I will make the binder-rich matrix with the fines and higher binder content, and many times we stabilize them using some polymers or fibers as well. So, we make these mixes more durable and stronger, especially for creating long-lasting pavements or for expressways or national highways with very high traffic of more than 100 MSA or 150 MSA. So very popular among national highways and expressways, in that case.

So now there are again gradations that have been specified for SMA as well. So you can preferably go for one SMA gradation as a binder course and the other as a wearing course. But SMAs are not used as your basic courses. So they are used as a binder, of course. The two gradations, if you want to work with those two gradations, can use one of them with a higher NMAAS as a binder course and the other one with a smaller NMAAS as your wearing course.

You can see these two gradations again: NMAAS of 13 and NMAAS of 19. So, if I am given the choice, I would prefer to use DBM-2 as my binder course, specifically the one with 1 inch or 25 mm NMAAS. I will use this particular one as a binder course; then I will put an SMA with this gradation, which I will call say 2, with a 19 mm NMAAS, and on the top, I will put this SMA, which has a 13 mm NMAAS. So, this will be my wearing course, this will be my binder course, and this will be my base. So, this combination you have to smartly pick up to understand how things work out, and specifically this is because of the gap-graded aggregate gradation; these mixes even provide you with high skid resistance compared to the other conventional disc-graded mixes. So, this is again an important advantage; because of this gap gradation, the coarser aggregate gradation provides better skid resistance compared to what you get with the dense-graded bituminous concrete mixes.

So, it is very important to choose these different types of dense graded mixes or gap graded mixes for use in your bituminous bound courses. We will continue this discussion in our next lecture. Thank you.